Ontology-based Recommendation System for Personalized Education of Dyslexics to Read

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Abstract. Dyslexic pupils have learning difficulties in reading, writing, maths. They require individualised education. The paper presents an approach to achievement of personalised teaching the basics of reading that applies dyslexic learner' profile ontology and learning goals ontology. A general model of reading that is rationale for determination of the latter is proposed. Ontology of dyslexia disabilities is suggested for manual annotation of learning resources.

Keywords: ontology, adaptation, e-learning, reading, dyslexia

1 Introduction

Learning difficulty (LD) is an umbrella term, described by physicians in neurological terms, while the educators consider it as an educational problem. It covers a wide variety of manifestations. Dyslexia – the most common of them is serious problem as it affects considerable part of children (between 5% and 17%). Dyslexic children have average or above-average intelligence but may have difficulties in mathematics, fine movements and below-average reading performance including problems with reading as decoding, comprehension or fluency. It is thought that specific violations of sense perceptions and processing information cause dyslexia. Its forms vary significantly because of the diversity of violations, so it could be divided into three cognitive subtypes: auditory, visual and attention [1]. From cognitive perspective, children may have difficulty with sequencing things, word recognition and comprehension, etc.

The most popular pedagogical approach, used for pupils with LD is multisensory approach of Orton-Gillingham [2], which apples action-oriented strategy that affects most of the sensor channels. The sensory-cognitive approach [3] allows design of optimal language-based, flexible, structure and sequential learning. It teaches students with weak phonemic and phonological awareness "how to learn", aiming to develop the underlying brain functions. These approaches focus on specifics as phonological skills, word analysis and recognition, spelling, fluency, grammar, and comprehension.

E-learning environments should be able to support learning activities in conformity with needs and preferences of learners. The LMS based on IMS LD can't be adapted to the specific learning needs of dyslexics. Adaptivity should concern course delivery, interaction, collaboration, content discovery and as-

sembly, etc. Adaptive course delivery that tailor a course to the learners needs, supposes effective semantic search and evaluation of external resources, reuse of learning units, and personalized resource delivery. IMS LD standards couldn't meet these requirements, as they do not provide machine - processable specifications of the subject domain (SD) knowledge.

The paper presents an approach to personalization of an e-learning environment by recommendation of suitable learning resources (LR) to dyslexics' learner according to his particular LD (described in his learning profile), learning background and learning goals (LG). To automate this process we use learners' profile and LG ontologies. A general model of reading that serves for rationale to determine LG and their ontology is presented. Our ontology of dyslexia disability classification is applied for resource annotations that are used for LR-recommendation agents supporting course authoring.

2 Ontology-Based Approaches to Adaptive E-Learning

Ontologies enrich the descriptive nature of Learning Object (LO) metadata, adding semantic information and enabling reasoning about metadata. In e-learning they are used for enhancing LO reusability and for achievement of various goals: knowledge representation in intelligent educational systems; interoperability between learning applications; sharable learners models and knowledge components by mapping ontologies; conceptualizing metadata; description of resources in learning facilities' repositories and semantic searching [4]; support of collaborative authoring; achieving personalization and adaptability in systems supporting collaborative learning [5].

Represented in mashine-prosessable way SD knowledge, LO or learner's profile metadata are used in automation and supporting almost all LMS activities: teaching, authoring, planning lessons, development and evaluation of assessment examinations [6, 7], and collaboration [8]. The ontology is used for representation of the semantics of the IMS Learning Design (IMS LD) specification and main elements of learning design process necessary for construction of a meta-language. An evaluation platform for open question and publication of exams in e-learning standard formats is proposed in [7] on the base of ontology. Some e-learning systems use many ontologies -Student Model ontology, Domain ontology, Learning Paths ontology, which specify aspects of learning design, and Content Structure ontology, Content Type ontology, User Model ontology that ensure reusing of content units at different levels of granularity [9]. It enables on-the-fly assembly of new LO compliant to the student's knowledge background, his preferences and learning style. Others provide a very flexible and user-friendly model and technology for organization and accessing educational content and evaluation of learning results. One of the main goals of this environment is to increase the reusability of available LR by using course domain ontology (for every course). TM4L e-learning environment uses e-LO ontology and user profile ontology as instrument for key metadata representations, needed for composition of on-demand courses according to individual learner abilities and preferences. It uses the web 2.0 FOAF Realm ontology as part of learner profile ontology so that it incorporates web 2.0 technologies as SSCF (social semantic collaborative filtering), tagging, and bookmaking as elements of collaborative personalized learning process. A multi-model ontol-

ogy-based framework for semantic search of educational content in e-learning repository of courses, lectures, multimedia resources, etc. is given in [4]. It serves for development of a hybrid recommender system providing two types of recommendations: content-based and rule-based (learner's interest-based).

According to us a subject domain can be regarded as a learning area, where learning goals are determined. The domain ontology can represent the main learning goals and their interrelationships. It can serve for representation of learner's achievements (experience) in the specific subject domain and description of learning facilities (resources) that are necessary to accomplish learning goals determined in this domain.

3 General Model of Reading

Reading is a visual-auditory task that has two main elements: processes of decoding text and understanding. While decoding bases on cognition of symbol-phoneme correlation, text understanding requires comprehension of context-independent words' meaning. The interdependent components of reading basis are: visual identification and memory, symbol-phoneme correlation, lexical-semantic memory. The *bottom-up* approach to reading bases on the following steps: letters and word recognition, and determination of word meaning. It requires translation of symbols into phonemes and understanding of phonemes' value. The top-down approach supposes that the readers use their experience to prognosticate certain words or phrases and then recognizes words and letters. The reading process usually integrates the two models.

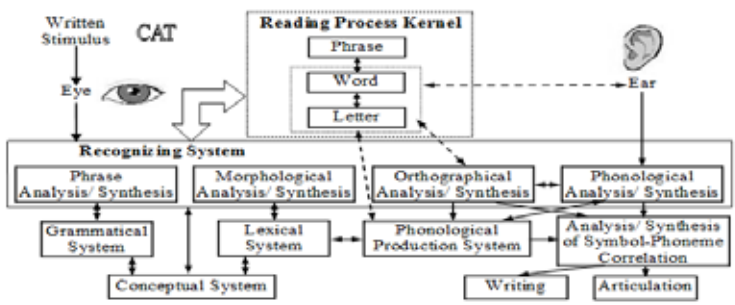

Fig. 1. General model of reading.

The model of reading shown on Fig. 1 comprises three functional sub-systems: [10] *recognizing, supporting and producing systems*. The Orthographical-Phonological system is responsible for the identification of a letters/ phonemes, the orthographical and phonological analysis/ synthesis and spelling in words. Its functional sub-groups work in collaboration and determine the symbol-phoneme correspondence.

According to the general model of reading the following essential learning goals, concerning only orthographical-phonological basis of reading literacy are derived:

1. Establishing associations between sounds and letters:
   1.1. Learning letters as a symbol: *Introducing* elements of letters; *Construction* of letter from its basic ingredients; *Decoding* letter in various appearance according to its parameters (size, font, colour, orientation); *Recognition* of single letter among other letters; *Naming* letters; *Representing* sounds with concrete visual objects (letters).

1.2. Development of phonological awareness: *Identification of single phoneme* (achievement awareness of the specific articulator motions associated with different speech sounds - mouth movements' pictures/ animation; decoding of various sound appearance depending on its parameters – volume, speed, power); *Identification of sound/ phoneme among others* in words (marking the sound in phoneme model of word at the beginning/ ending/ middle); *Association* of sounds with concrete letters.

2. Developing sensitivity to the sound structure of words:
   2.1. Acquiring sensitivity to the sequences of sounds in syllables: *Dividing* words on syllables; *Counting* syllables in words; *Representing* syllables structure of word.
   2.2. Phoneme segmentation and blending.

An ontology representation of the above goal-oriented description is shown on Fig. 2.

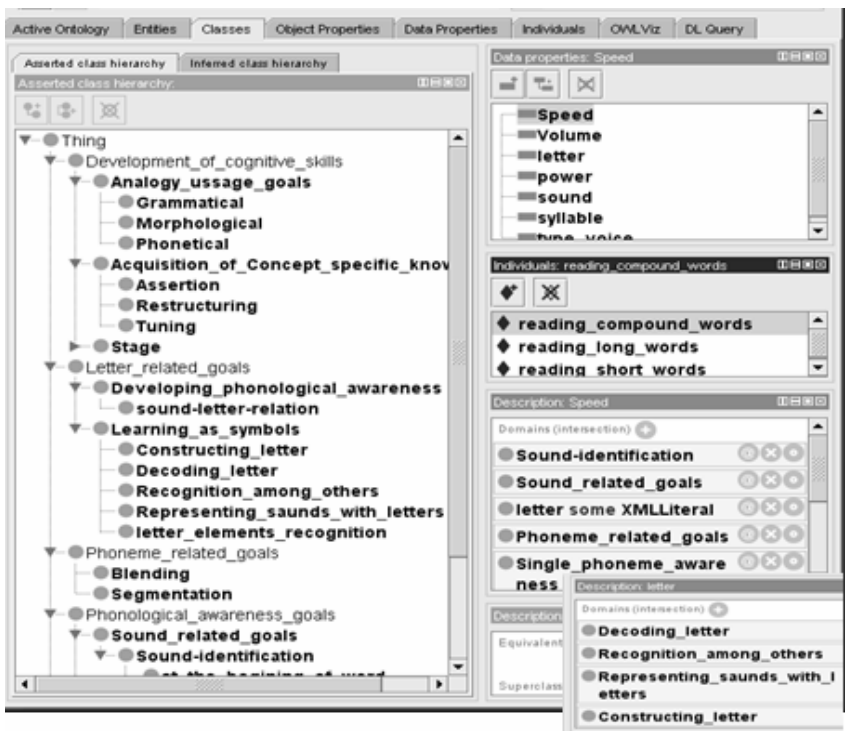

Fig. 2. Ontology of goal-oriented description of orthographical-phonological sub domain.

4 Modeling Dyslexic Learner's Profile

Dyslexic learner's profile contains information about learner features and its learning characteristics needed for personalization. It includes all significant learners' profile aspects: personal, personality, learning style and preference data. Personal data comprises biographical information. The personality presents individual manners during learning process. The preference data reveals learners' preferences regarding presentation format, content display, sound and video parameters, etc. The learning style depends on learners' competence (specific learning deficits, cognitive abilities, educational background), learn-

ing goals and subject domain. We analyze and classify specific learning deficits/ disabilities presented in dyslexia-related studies, which are needed for semantic description of dyslexic learner profile (see Fig. 3). Data about the level of manifestation of each individual's deficit is of great importance for learning resource selection, learning goal definition and learning process organization. We use a FOAF ontology for representation of dyslexia disabilities classification necessary to select LR and organize teaching. A part of our classification is shown on Fig. 3.

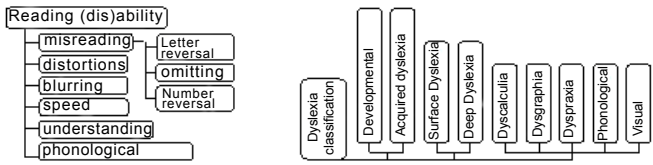

Fig. 3. Dyslexia disabilities classification.

5 Conclusion

The disability to read and comprehend is a major obstacle for learning, so it has long-term educational and social effects. Children with LD should receive appropriate support and personalized education. It is presented an ontology-based approach to adaptive e-learning for dyslexics. The approach has sufficient power to represent all the diversities in dyslexic learner's personal features. Ontological representation of dyslexia-related knowledge make possible computational reasoning about learning disabilities and needs of every learner and recommending him LR, best suited to his needs. The ontological reasoning is used as a separate high-level layer in modular e-learning systems (including web 2.0 based ones) to ensure flexibility, automation, and high quality development and recommendation tools for dyslexia learners.

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